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**Committee on the Peaceful Uses of Outer Space**

# Activities carried out in 2020 in the framework of the workplan of the International Committee on Global Navigation Satellite Systems

**Report of the Secretariat**

## I. Introduction

1. The International Committee on Global Navigation Satellite Systems (ICG) is a forum established to facilitate discussion on the benefits of global navigation satellite systems (GNSS) to people around the world and to promote the use of those systems and their integration into infrastructure, in particular in developing countries. ICG and its Providers' Forum aim to promote greater compatibility and interoperability among current and future providers of GNSS and regional navigation satellite systems, encouraging the development of complementary systems, and to address key issues, such as ensuring the protection of the GNSS spectrum and matters related to orbital debris and orbit deconfliction.

2. The Office for Outer Space Affairs, as the executive secretariat of ICG, coordinates the planning meetings of ICG and its Providers' Forum, as well as the intersessional meetings of the ICG working groups held in conjunction with sessions of the Committee on the Peaceful Uses of Outer Space and its subsidiary bodies.

3. The fifteenth meeting of ICG, originally scheduled to take place at the Vienna International Centre in September 2020, was postponed in the light of guidance severely limiting in-person meetings as a result of the coronavirus disease (COVID-19) pandemic. The members of ICG therefore agreed on new dates for its annual meeting, to be held at the Vienna International Centre from 27 September to 1 October 2021. The meeting will be chaired by the Office for Outer Space Affairs. Detailed information about the meeting is available on the ICG information portal.[1]

4. The activities and opportunities provided through the ICG programme on GNSS applications and implemented by the Office result in the development and growth of capacities that will enable each country to enhance its knowledge, understanding and practical experience in those aspects of GNSS technology that have the potential for a greater impact on its economic and social development, including the preservation of the environment.

5. The present report contains a description of the activities undertaken or supported by the Office for Outer Space Affairs during 2020 and the main results achieved. Detailed

[1] See www.unoosa.org/oosa/en/ourwork/icg/meetings/icg-15/icg15.html.

information on those activities is available on the ICG information portal.[2] The report has been prepared for submission to the Committee on the Peaceful Uses of Outer Space at its sixty-fourth session and to the Scientific and Technical Subcommittee at its fifty-eighth session, both to be held in 2021.

# II. Activities of the International Committee on Global Navigation Satellite Systems carried out in 2020

6. Pursuant to the ICG workplan for 2020 and the recommendations contained therein, the Office for Outer Space Affairs, in partnership with members, associate members and observers of ICG and international entities, focused on: (a) disseminating information through the information centres hosted by the regional centres for space science and technology education, affiliated to the United Nations; (b) promoting the use of GNSS as tools for scientific applications; and (c) building the capacity of developing countries in using GNSS technology for sustainable development.

## A. Information dissemination through the information centres hosted by the regional centres for space science and technology education, affiliated to the United Nations

7. The Office for Outer Space Affairs, through the United Nations Programme on Space Applications, supports the operation of the regional centres for space science and technology education, affiliated to the United Nations, in Africa (Morocco and Nigeria), Asia and the Pacific (China and India), Latin America and the Caribbean (Brazil and Mexico) and Western Asia (Jordan).

8. The regional centres also act as information centres for ICG. Links have been established through collaboration with the ICG working groups and the Providers' Forum in carrying out seminars and training events and providing support materials, as well as in communication and outreach to the wider community through the ICG information portal and brochures and newsletters on global applications of GNSS.

## B. Promoting the use of global navigation satellite system technologies as tools for scientific applications

### 1. Space weather effects on global navigation satellite systems

9. Space weather refers to conditions on the Sun, in the solar wind and in the magnetosphere, ionosphere and thermosphere, which can influence the performance and reliability of a variety of space-borne and ground-based technological systems. It is recognized as the cause of significant errors experienced by GNSS and satellite-based augmentation systems (SBAS). GNSS or SBAS signals propagating from a satellite to the user receiver pass through the ionosphere, where they are subject to space weather effects. Under those conditions, pseudorange errors and signal scintillations at the user receiver level may occur.

10. Given the fluid nature of the COVID-19 outbreak, the ICG executive secretariat, in cooperation with the Abdus Salam International Centre for Theoretical Physics (ICTP) in Italy, the Institute for Scientific Research at Boston College in the United States of America and the United Nations-affiliated African Regional Centre for Space Science and Technology – in French Language in Morocco, transformed an African workshop on GNSS and space weather, planned to be held in Rabat from 5 to 16 October 2020, into a virtual workshop. That special virtual workshop, conducted on 5 and 6 October 2020, brought about new opportunities, allowing 204 invited participants, 30 per cent of whom were women, to represent GNSS interests in

[2] See www.unoosa.org/oosa/en/SAP/gnss/icg.html.

45 countries. Broadening workshop participation proved highly beneficial, as interest in GNSS around the world is increasing rapidly.

11. The objective of the workshop was to provide attendees with an introduction to ionospheric physics and the science of space weather, including a basic knowledge of GNSS technology and its applications. The workshop also focused on space weather research using GNSS data. Instructions were provided on how to obtain GNSS total electron content data from the Madrigal database (http://cedar.openmadrigal.org/). The database, which is capable of managing and making available archival and real-time data in a variety of formats, contains information from a wide range of upper atmospheric science instruments. Detailed information about the workshop is available on the website of ICTP.[3]

12. The following countries were represented at the workshop: Algeria, Australia, Belgium, Bhutan, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Colombia, Côte d'Ivoire, Croatia, Egypt, Estonia, Ethiopia, Fiji, Gabon, Ghana, Guinea, India, Indonesia, Italy, Kenya, Mauritius, Mongolia, Morocco, Nepal, Niger, Nigeria, Pakistan, Peru, Philippines, Rwanda, Senegal, Somalia, South Africa, Sri Lanka, Thailand, Togo, Uganda, Ukraine, United Republic of Tanzania, Uzbekistan, Venezuela (Bolivarian Republic of) and Zambia.

13. The lecturers at the workshop included GNSS experts from the European Commission, France, Morocco and the United States, as well as from ICTP and the Office for Outer Space Affairs.

### 2. Global navigation satellite systems data processing

14. High-precision positioning can be achieved by combining GNSS, such as the Global Positioning System (GPS) of the United States, the Global Navigation Satellite System (GLONASS) of the Russian Federation, the European Satellite Navigation System (Galileo) and the BeiDou Navigation Satellite System (BDS), with real-time kinematics (RTK) technology, which uses the receiver's measurements of the phase of the satellite signal's carrier wave. Combined with corrections from a local or virtual base station, those measurements allow the receiver to solve carrier ambiguities and provide the end user with position information that is accurate to the level of a centimetre.

15. A GNSS receiver can provide accuracy to the level of a centimetre with a low-cost receiver if an error correction technique is used. Thus, the availability of low-cost and high-accuracy receivers will pave the way for new navigation applications.

16. The Centre for Spatial Information Science at the University of Tokyo, the Geoinformatics Centre of the Asian Institute of Technology (AIT) in Thailand and the ICG working group on information dissemination and capacity-building (Working Group C), led by the Office for Outer Space Affairs, organized the third training course on GNSS in a series of three courses held from 2018 to 2020, which was aimed at raising awareness of GNSS technology and its applications in the Asia and the Pacific region. The third course was held at AIT from 6 to 10 January 2020 and provided knowledge about the use of low-cost GNSS receiver systems and Android devices for high-accuracy positioning, survey methods and data processing for high accuracy in real-time or post-processing modes.

17. The training course was conducted in two parallel sessions: (a) a GNSS training course focusing on GNSS technology and its applications, RTKLIB (an open source programme package for GNSS positioning) and related software for high-accuracy GNSS data processing (http://www.rtklib.com/), a field survey using a low-cost receiver for high-accuracy positioning and GNSS data processing for post-processing RTK; and (b) a course on GNSS for policymakers and decision-makers that focused on various types of GNSS receivers, antennas and software.

[3] See http://indico.ictp.it/event/9124/.

18. A total of 71 specialists, 24 per cent of whom were women, from 15 countries participated in and contributed to the training course in 2020. Funds provided by the European Commission and the United States through ICG were used to defray the costs of air travel for 18 engineers and graduate students from Algeria, Bangladesh, India, Malaysia, Maldives, Mongolia, Nepal, Pakistan, the Philippines, Sri Lanka and Viet Nam. The lecturers included GNSS experts from Japan, Nepal and the United States, as well as from the Office for Outer Space Affairs. Detailed information about the training course is available on the ICG information portal.[4]

19. A total of 217 specialists from the Asia and the Pacific region attended the training courses in the period from 2018 to 2020, and 57 trainees from 15 countries were supported by ICG through the Office for Outer Space Affairs. As a follow-up to the series of training courses, a handbook on high-accuracy GNSS data processing, summarizing data processing techniques, error analysis and various concepts relating to the set-up of base stations, rover units and software, all of which were discussed during the training sessions, will be prepared by the expert group of Working Group C for future reference.

## C. Building the capacity of developing countries in using global navigation satellite system technology for sustainable development

### 1. Regional workshops on applications of global navigation satellite systems and the International Space Weather Initiative

20. As a result of the COVID-19 pandemic, the United Nations/Mongolia workshop on the applications of global navigation satellite systems was rescheduled from 2020 to 2021. The workshop is being organized by the Office for Outer Space Affairs in cooperation with the Mongolian Geospatial Association and the Agency for Land Administration and Management, Geodesy and Cartography of Mongolia and will be held in Ulaanbaatar from 25 to 29 October 2021. The main objectives of the workshop will be to enhance the exchange of information between participating countries on the applications of GNSS solutions and, to that end, scale up capacities in the Asia and the Pacific region, including by sharing information on national, regional and global projects that may provide benefits for the region and thereby enhance cross-fertilization among those projects.

21. The United Nations/India workshop on the International Space Weather Initiative (ISWI), planned to be held in Thiruvananthapuram, Kerala, India, in 2020, was postponed until 2021. The workshop will be organized by the Office in cooperation with the Vikram Sarabhai Space Centre of the Indian Space Research Organization. The focus of the workshop will be on recent advances made in scientific research by utilizing ISWI instrument data in conjunction with space data.

22. Detailed information about the workshops is available on the website of the Office for Outer Space Affairs (www.unoosa.org).

### 2. Long-term fellowship programme on global navigation satellite systems and related applications

23. A second-level specializing master's programme in navigation and related applications was organized as a joint initiative of the Office for Outer Space Affairs, the Politecnico di Torino, the Istituto Superiore Mario Boella (now part of the LINKS Foundation), and the Istituto Nazionale di Ricerca Metrologica in Italy, from 2005 to 2018. The purpose of the programme was to provide young graduates with high-quality training, professional knowledge and skills needed in the satellite navigation sector.

24. The programme provided extensive background knowledge on navigation/localization systems, as well as detailed analysis of navigation/communication

[4] See www.unoosa.org/oosa/en/ourwork/icg/activities/2020/ait2020-gnss.html.

integration and environmental monitoring applications. The programme's curriculum was structured to meet effectively the market demand for high-level technicians endowed with a broad vision of the state of the art in navigation/localization as well as specific skills.

25. From 2005 to 2018, more than 189 students from five continents, 20 per cent of whom were women, received relevant high-quality training in the field of satellite navigation and its applications. The largest share of students, about 49 per cent, were from the Asia and the Pacific region, while 19 per cent of trainees were from Europe, 16 per cent from Africa, 15 per cent from Latin America and the Caribbean and about 1 per cent from Oceania. The Office for Outer Space Affairs contributed to the selection of more than 30 per cent of the trainees who graduated from the master's programme. The Office also provided funds to defray the costs of air travel for selected participants. Most trainees now hold top-tier positions in the field of GNSS in institutions at the regional and/or national level and in the private sector. The trainees also took part in activities carried out by the Office in the framework of the Programme on Space Applications and the ICG programme on GNSS applications.

26. The Politecnico di Torino and the Office are currently evaluating the possibility of overhauling and reorganizing the master's programme by broadening the subject areas covered and adding new elements pertinent to GNSS/Galileo and their applications.

# III. Technical advisory services

27. In order to inform a wide audience about the current status and future role of ICG in a multi-GNSS arena and to receive feedback from the entire GNSS community, the Office for Outer Space Affairs participated in and contributed to the following international conferences held in person and/or online in 2020:

(a) Fifteenth Ilan Ramon International Space Conference, entitled "2020–2030: predicting the next space decade", held in Tel Aviv, Israel, on 28 January 2020;

(b) Tenth Space Weather Conference, held on Jeju Island, Republic of Korea, on 26 and 27 October 2020;

(c) Eleventh China Satellite Navigation Conference, held in Chengdu, China, from 23 to 25 November 2020.

28. The Office contributed to the heliophysics seminar organized by the Solar Physics Laboratory of the National Aeronautics and Space Administration Goddard Space Flight Center on 10 July 2020. A presentation on building the capacity of developing countries in using GNSS technology for sustainable development highlighted the activities of the ICG programme on GNSS applications and its plans for 2021, as well as the work carried out by the ICG working groups.

29. The Office also contributed to a panel discussion on the topic "Multilateralism at work", showcasing examples of collaboration in space affairs, organized by the European Union in collaboration with the Office and held in Vienna on 4 February 2020. The Office contributed to the discussion on how cooperation between the European Union and the Office contributes to the Sustainable Development Goals and multilateralism. The work carried out by ICG and its working groups was also introduced.

30. The Office organized a World Space Week 2020 webinar series entitled "Satellites to improve lives". In a webinar held on 7 October 2020, through a presentation on satellites for GNSS and the role of ICG, it was discussed how GNSS was currently used in various applications in science and technology, along with examples of projects and initiatives carried out by the ICG working groups. The attendees were very appreciative of the opportunity to take part in the webinar and to get to know how the Office helps countries to gain access to satellite applications for

use in various areas, including for capacity-building, training and research in the field of GNSS.

31. The Office also organized and chaired a preparatory meeting for the fifteenth meeting of ICG. The preparatory meeting was held in Vienna on 10 February 2020, on the margins of the fifty-seventh session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

32. In order to make further progress on the workplans of the ICG working groups and their recommendations, the working groups and their subgroups held a series of virtual intersessional meetings in the period from June to September 2020.

33. Following the ICG recommendation (see A/AC.105/1217) outlining the need for consultation with the Inter-Agency Space Debris Coordination Committee (IADC) regarding a study on the issue of debris mitigation practices relevant to the medium Earth orbit and inclined geosynchronous orbit orbital regimes used for GNSS, IADC submitted to the ICG executive secretariat an interim report on the benefits and risks associated with medium Earth orbit disposal options in October 2020. The interim report was circulated to all members of ICG for consideration, and IADC had already taken further action to continue working on the issue in order to develop methods for quantifying and evaluating the resulting benefits and risks of the different disposal methods presented in the interim report.

# IV. Voluntary contributions

34. In 2020, ICG activities were successfully implemented thanks to the support and voluntary contributions, both financial and in kind, provided by members:

(a) The United States provided $100,000 to support capacity-building and technical advisory services and arranged for experts to make technical presentations and participate in discussions during activities described in the present report;

(b) The European Commission provided €100,000 to support capacity-building and technical advisory services and arranged for experts to make technical presentations and participate in discussions as part of activities described in the present report;

(c) The other members, associate members and observers of ICG also made technical presentations and participated in discussions at events described in the present report.